55

INFLUENCE OF SERIAL GEISSLER TUBES ON THE PRODUCTION OF JOSHI-EFFECT IN AN OZONISER DISCHARGE

By B. N. PRASAD and NARENDRA NATH

(*Received for publication, June 17, 1948*)

ABSTRACT. The production of Joshi-effect Δi is studied with and without Geissler type discharge tubes in the low tension (L. T.) line of a chlorine filled ozoniser excited by 5·8 kV of 50 cycles frequency. A double diode coupled inductively with L. T. was the detector. The 100% relative Joshi-effect observed in i_m with neon tube is attributed to the HF's which, according to Joshi, are the chief seats thereof. The sharp reversal of the Joshi-effect from negative to positive and once again to negative in the filtered i_m with neon tube, and the observation of positive effect at large V in i_m with helium tube by mere potential variation have been attributed to simultaneous occurrence of $\mp \Delta i$ in the current. That i at low V is less with the tube than without it and that at large V this order is reversed, are explained by an extension of the relation between V and ozonizer current i due to Joshi.

INTRODUCTION

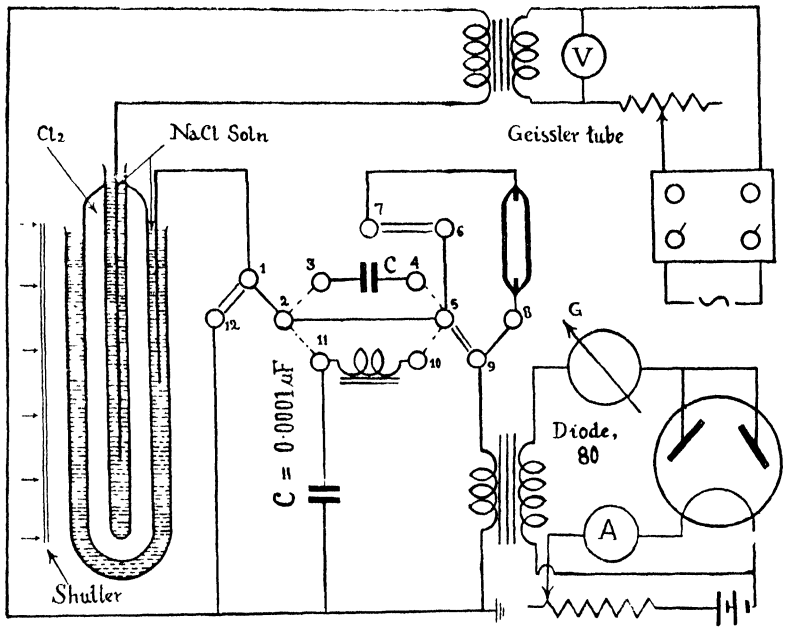
The present work arose out of Joshi's (1945 *b*) observation of an optical demonstration of the Δi phenomenon, *viz.*, that the luminescence in a Crookes' or Geissler tube coupled with the low tension (L. T.) line of a chlorine filled ozoniser is quenched instantaneously and reversibly on irradiating the latter, to give the negative Joshi-effect $-\Delta i$. Joshi (1943, 1044*b*, 1945*a*) has established that the HF's produced under the discharge constitute a chief seat of the effect $-\Delta i$. The marked potency of the HF's in the electrical obliteration of a nitrogen after-glow (Joshi and Purushotham, 1938) and in the excitation of the luminescence of the above type tubes is known. It appeared, therefore, desirable to study in some detail the comparative production of the Joshi-effect $\mp \Delta i$ with and without the above tubes introduced in the path of the discharge.

EXPERIMENTAL ARRANGEMENT

Chlorine, purified carefully by fractionation over liquid air, was admitted to the annular space of a precleaned and degassed (by repeatedly subjecting to discharge at high potentials and evacuating on the Töpler) ozoniser, at a pressure of 300 mm. Hg. It was excited by a transformer discharge of 50 cycles frequency, and Joshi-effect $\mp \Delta i$ was observed from values of the discharge current in dark (i_D) and when the ozoniser was irradiated with a 220 volt

200 watt incandescent (glass) bulb (i_b). The current i was measured with a double diode 80 connected through a Bell transformer (1:3) with the ozoniser. The general technique and experimental arrangement were essentially as described previously. The relative Joshi-effect $\%\Delta i$ is given by $100\ \Delta i/i_b$. Table I records four series of experiments that were carried out. First, with what is called 'normal' circuit, *i.e.*, when only the ozoniser was excited; and when, in series with it, a neon, helium, or nitrogen-filled Geissler type tube was introduced between the low tension terminal of the ozoniser and earth (*vide* Fig. 1). Under each of the four series of experiments mentioned

Fig 1



above, i_b, i_t, Δi and $\%\Delta i$ were observed in the high frequency component (i_H), and the low frequency component (i_L) of the discharge current (i_T), in the following manner: In the first series (with 'normal' circuit, *i.e.*, in absence of a Geissler tube in the circuit) the connections 1, 2, 5 and 9 were made (Fig. 1). This gives i_L. The ozoniser was excited in the range 5 to 8 kV; the corresponding values for i_b, i_t, Δi and $\%\Delta i$ are expressed graphically in Fig. 2. The HF component i_H was next observed by connecting 1, 2, 3, 4, 5 and 9. Lastly, the HF's were filtered out by by-passing through the capacity C, when the detector measured i_L, the connections being 1, 2, 11, 10, 5 and 9 which included an HF choke between 11 and 10 (Fig. 1).

During next part of the work, each of the Geissler tubes mentioned above was introduced in the path of the discharge by connecting 1, 2, 5, 6, 7, 8 and 9. The corresponding i_H and i_L were observed with connections ex-

Table I

Influence of Serial Geissler Tubes on the Comparative Joshi-Effect in Chlorine in the Low and High Frequency Regions of the Discharge Current

kV		Normal			With neon tube			With helium tube		With nitrogen tube	
		i_{LF}	i_{HF}	i_{HF}	i_{LF}	i_{HF}	i_{HF}	i_{LF}	i_{HF}	i_{LF}	i_{HF}
5.1	i_D	66	51	18	96	22	3	—	—	52	—
	i_L	44	28	3	86	10	1	—	—	44	—
	Δi	— 22	— 23	— 15	— 10	— 12	— 3	—	—	— 8	—
	$\%\Delta i$	— 33	— 45	— 83	— 10	— 54	—100	—	—	— 15	—
5.3	i_D	122	75	66	133	60	6	—	—	89	—
	i_L	73	54	29	129	52	0	—	—	49	—
	Δi	— 49	— 21	— 37	— 4	— 8	— 6	—	—	— 20	—
	$\%\Delta i$	— 40	— 28	— 56	— 3	— 13	—100	—	—	— 29	—
5.6	i_D	168	92	129	206	78	10	—	—	124	40
	i_L	96	67	100	199	84	0	—	—	102	35
	Δi	— 72	— 25	— 29	— 7	+6	— 10	—	—	— 22	— 5
	$\%\Delta i$	— 43	— 27	— 22	— 3	+7	—100	—	—	— 18	— 12
5.9	i_D	230	110	214	289	102	14	—	—	180	70
	i_L	136	75	161	271	106	1	—	—	170	55
	Δi	— 94	— 35	— 53	— 18	+4	— 13	—	—	— 10	— 15
	$\%\Delta i$	— 41	— 32	— 25	— 6	+4	— 92	—	—	— 6	— 21
6.1	i_D	265	120	280	349	157	19	195	49	249	121
	i_L	149	79	224	324	189	2	135	20	234	85
	Δi	—116	— 41	— 56	— 25	+32	— 17	— 60	— 29	— 15	— 36
	$\%\Delta i$	— 44	— 35	— 20	— 7	+20	— 89	— 30	— 59	— 6	— 29
6.4	i_D	290	131	347	391	202	23	245	94	321	152
	i_L	163	80	264	374	253	3	170	36	299	133
	Δi	—127	— 51	— 83	— 17	+51	— 20	— 75	— 58	— 22	— 17
	$\%\Delta i$	— 44	— 39	— 24	— 4	+25	— 87	— 31	— 62	— 7	— 11

Table I (*contd*)

		Normal			With neon tube			With helium tube		With nitrogen tube	
		i_{LT}	i_{LF}	i_{HF}	i_{LT}	i_{LF}	i_{HF}	i_{LT}	i_{HF}	i_{LT}	i_{HF}
67	i_D	330	142	379	430	207	24	274	119	374	232
	i_L	180	85	286	405	288	3	230	64	339	227
	Δi	—150	— 57	— 93	— 25	+81	— 21	— 44	— 55	— 35	— 5
	$\%\Delta i$	— 45	— 40	— 25	— 6	+39	— 87	— 16	— 46	— 9	— 2
69	i_D	362	153	398	479	223	29	420	156	424	
	i_L	185	86	316	466	268	5	348	114	378	315
	Δi	—177	— 67	— 82	— 13	+45	— 26	— 72	— 42	— 46	300
	$\%\Delta i$	— 49	— 44	— 21	— 3	+20	— 89	— 21	— 27	— 11	— 15
											— 5
72	i_D	385	165	459	520	202	33	495	184	471	
	i_L	200	90	345	514	167	3	444	114	405	365
	Δi	—185	— 75	—114	— 6	— 35	— 30	— 51	— 70	— 66	350
	$\%\Delta i$	— 48	— 45	— 27	— 1	— 17	— 90	— 10	— 37	— 14	— 15
											— 4
75	i_D	422	170	509	544	202	35	584	259	499	440
	i_L	220	93	372	539	116	4	542	244	439	390
	Δi	—202	— 77	—137	— 5	— 86	— 31	— 42	— 15	— 60	— 50
	$\%\Delta i$	— 48	— 45	— 27	— 0	— 42	— 88	— 7	— 6	— 12	— 11
77	i_D	414	175	539	584	192	39	640	344	539	459
	i_L	196	99	400	567	122	4	610	259	450	417
	Δi	—218	— 76	—139	— 17	— 70	— 35	— 10	— 85	— 89	— 42
	$\%\Delta i$	— 49	— 44	— 26	— 3	— 36	— 89	— 2	— 25	— 16	— 9
80	i_D	475	180	579	615	182	43	710	424	570	505
	i_L	243	105	336	355	144	4	680	339	489	464
	Δi	—232	— 75	—143	—260	— 38	— 39	— 30	— 85	— 81	— 41
	$\%\Delta i$	— 49	—441	— 25	— 42	— 21	— 90	— 4	— 20	— 14	— 8
82	i_D	—	—	—	—	—	—	745	471	—	—
	i_L	—	—	—	—	—	—	760	439	—	—
	Δi	—	—	—	—	—	—	+15	— 32	—	—
	$\%\Delta i$	—	—	—	—	—	—	+2	— 7	—	—

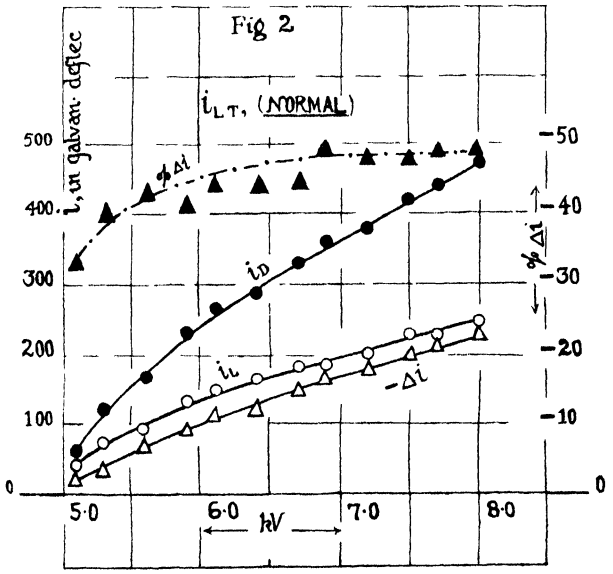
i_{LT}—Total current in the low tension line, i_{LF} and i_{HF}—the filtered low and high frequenev parts of the current in arbitrary units.

9—1674P—10

plained already. As illustrative of the generality of these results, one group of data obtained with the neon tube is shown by curves in Figs. 3 to 5.

DISCUSSION

Results in Fig. 2 (*cf.* also Table I) show that for the 'normal' discharge circuit, *i.e.*, when only the chlorine filled ozoniser was excited, the Joshi-

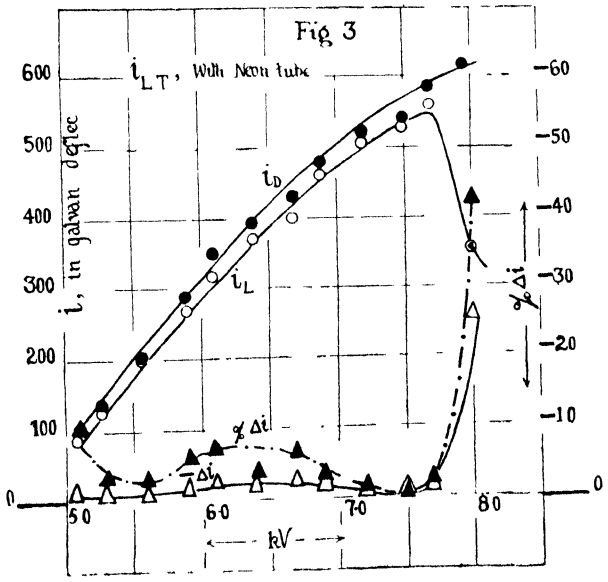


effect sets in above the 'threshold potential' V_m (Joshi, 1929, 1944 *b*) which was 5.1 kV. Above this potential, whilst the net Joshi-effect $-\Delta i$ increases (numerically) progressively upto the largest potential used, *viz.*, 8.2 kV, the relative effect tends to a limiting value of 49%. Due to the small size of the ozoniser used, the energy dissipation in the system was so low that no current could be detected in an aerial within even 3 ft from the ozoniser. On the introduction of a serial and by-pass capacity of 0.0001 μF in the LT line, the results show that relative Joshi-effect $-\%\Delta i$, is a maximum in i_m and least in i_{LT} in 'normal' circuit This is in accord with Joshi's (1944 *b*, 1945 *a*, 1945 *b*) general result that the HF's represent a chief seat of $-\Delta i$. That $-\%\Delta i$ is intermediate in i_D is due to the circumstance that it contains both HF's and LF's.

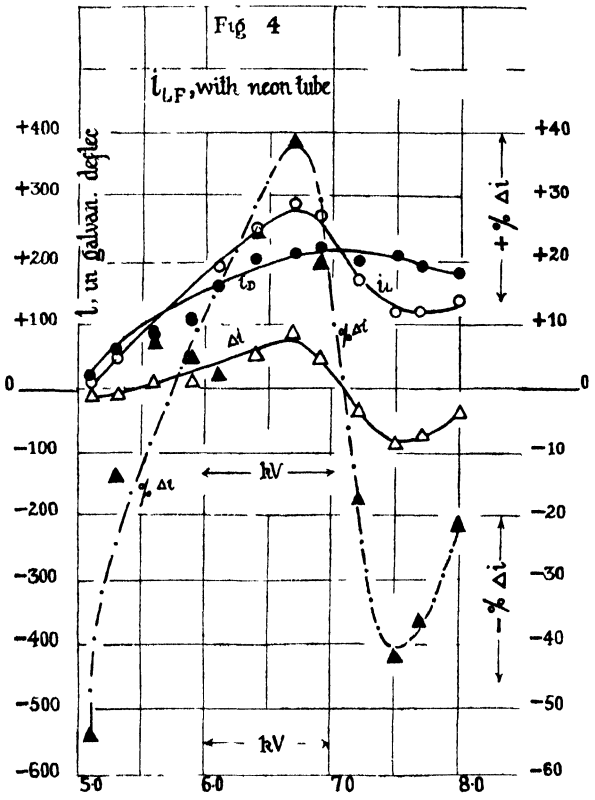
The presence of a Geissler vacuum tube in series with the ozoniser reveals pronounced alterations in the production of the Joshi-effect and also in the potential variation of the conductivity under the discharge, both in light and in dark. It is seen that at low potentials i is less with the vacuum tube than without it. At large V, however, the reverse is the case. With the nitrogen and the helium tubes i_{LT} was too small for detection with the available indicators. The corresponding Joshi-effect, however, is markedly

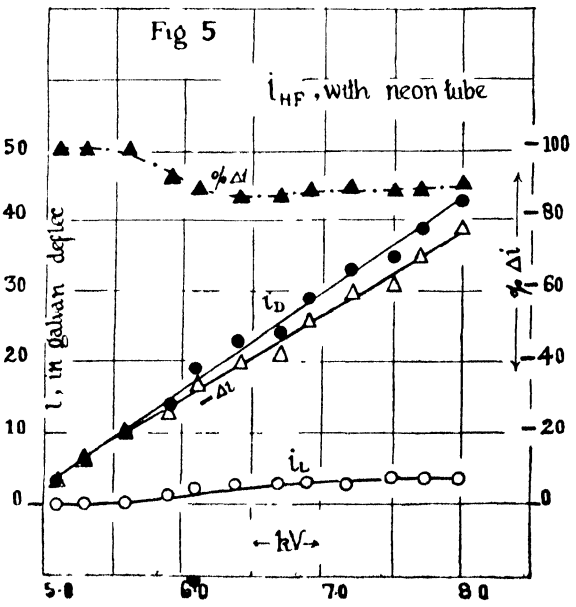
different. With nitrogen there is only $-\Delta i$; its (numerically) maximum value in nitrogen is less than the corresponding value with the neon and helium tubes. Using the latter, i_H shows a negative Joshi-effect of 30% at the 'threshold potential'; which decreases progressively with the applied V to about 4 at 8 o kV; and remarkably enough, changes sign to give a positive Joshi-effect of 2 to 6%. As is to be expected (*vide supra*), $-\%\Delta i$ is (numerically) larger in i_m, *viz.*, 59. which decreases rapidly with applied V, but does not change sign.

It may be recalled that the 'threshold potential' is located by observation of a rapid increase of current for a small rise of V. Below 5.1 kV, the indicator employed showed but negligible and variable current. This was also the case on the addition of the nitrogen tube. Its substitution by the helium tube increases V_m by about 1.0 kV. The absence of a marked change in i compared with the 'normal' on the addition of a nitrogen tube and also the decrease of i (especially at low exciting potentials) on the substitution by helium tube are explicable since according to a general result due to Joshi, i depends upon $V\text{-}V_m$ (Joshi, 1929, 1939, 1944*a*, 1945*a*). The deviations at larger V are considered later. When, however, the neon tube was introduced in the circuit, it was remarkable to observe that even at 1.5 applied kV, whilst the conductivity remained undetectibly low, the neon tube revealed its characteristic luminescence. This remained unaffected on irradiating the chlorine tube. Joshi considers that the proportion of the HF's in the corresponding current is marked near V_m and (unpublished results) that the discharge might start, though comparatively feebly, below V_m. The HF's produced at these low potentials might be responsible for causing the luminescence in the neon tube. The Joshi-effect Δi was, however, detected only near V_m, *i.e.*, at 5.1 kV, near which it is as high as 100%



current decrease, using i_{HF} under but ordinary light. The relative Joshi-effect $-\%\Delta i$ decreases (numerically) but slightly by increasing V and remains





constant at about 88 over 6.0 to 8.0 kV (Fig. 5). This behaviour differs strikingly from that observed in i_{II}. Here $\%\Delta i$ is -54 near V_m; and decreases (numerically) rapidly by increasing V and is undetected near 5.7 kV (Fig. 4). A further increase of V initiates a positive Joshi-effect (*i.e.*, a photo-increase of the current $+\Delta i$), which reaches a maximum of 40% at about 6.7 kV. An increase in V hereafter produces not only a precipitous decrease in the $+\%\Delta i$ but a reversal to the negative Joshi-effect of 40%; once again this decreases (numerically) by increasing V. It must be emphasised that the entire sequence of these observations could be reproduced practically any number of time. A reversible inversion by potential increase $+\Delta i \rightleftharpoons -\Delta i$ was observed by Joshi (1947) in Cl_2 under HF–excitation and at low frequencies when the relative surface was increased by introducing powdered wall material in the annular space of the ozoniser. A sharp reversal of positive to negative Joshi-effect (as shown by $\%\Delta i$ versus kV curve in Fig. 4) by mere potential variation was observed (Joshi and Bhutt, 1942; Joshi and Murthy, 1942) in iodine vapour excited by silent discharge and in chlorine under semi-ozoniser excitations (Joshi, 1947). The latter changes were, however, found to be markedly subject to 'ageing.'

The 'ageing' factor had no sensible influence under conditions in the present work. Data for the current i_{II} (Fig. 3) show only negative Joshi-effect variable in the range 10 to 40%, the latter increasing suddenly as the applied V is increased above 7.5 kV (*vide* infra). It may be mentioned at this stage that using i_{III} and a neon tube which produced a negative Joshi-effect of 88 to 100% near V_m, instantaneously with the irradiation, the luminescence in the neon tube was quenched practically completely and restored equally immediately on shutting off the light. When, however, the neon tube was introduced in the path of i_{II} the quenching was but partial. Using the i_{II} the neon luminescence quenched less markedly, corresponding to the negative Joshi-effect. At potentials producing the positive Joshi-effect (Fig. 4) the enhancement in the luminescence was much less than expected from the corresponding $+\%\Delta i$. The Geissler luminescence in the helium and more especially in the nitrogen tube was but slightly affected corresponding to the production of $-\Delta i$. It is suggested that the potency of HF's in exciting the luminescence decreases rapidly in the order neon > helium > nitrogen.

It is instructive to examine curves (of which only one group with neon tube is shown in Figs. 3, 4 and 5, in comparison with the 'normal' in Fig. 2, from Table I) showing the influence of V, on i_D, i, Δi and $\%\Delta i$ for the i_{II}, i_{III} and i_m lines, obtained with the 'normal' circuit and that containing one of the Geissler tubes employed in this work. It is seen that the influence of V on the various quantities mentioned above, especially the relative Joshi-effect $\%\Delta i$ deviates markedly with latter circuits than the former ('normal'). Thus, *e.g.*, it is seen that with a neon tube, $\%\Delta i$ fluctuates about a small value, except when it rises suddenly from about 0 to 40 within 7.5 to 8.0 kV.

Joshi (1943, 1945*a*, 1945*b*, 1946) has suggested that the conductivity in an ozoniser discharge is a vectorial sum of various frequency currents with relative phase differences; both positive and negative Joshi-effects of different magnitudes may be associated with them. The effect observed with a given detector is the resultant of the $\mp\Delta i$ linked with the frequency bands to which the detector is sensitive. Introduction of a frequency filter cannot initiate a new reaction leading to a $-\Delta i$ or $+\Delta i$ as the case may be. These are presumably present simultaneously in the current structure and its time-delineation under irradiation. The observation of a conspicuous positive effect in the filtered i_{LI} with a serial neon tube is in accord with this view.

ACKNOWLEDGMENT

In conclusion, we express our grateful thanks to Prof. S. S. Joshi, D.Sc. (London), F.N.I., F.R.I.C., for suggesting the problem and for the kind interest and valuable guidance during the progress of the work.

PHYSICAL CHEMICAL LABORATORIES,
BENARES HINDU UNIVERSITY.

REFERENCES

Joshi, 1929, *Trans. Faraday Soc.*, **25**, 120.

——— and Purushotham, 1938, *Proc. Indian Sci. Cong.*, Part III, Chem. Soc., p. 48.

———, 1939, *Curr. Sci.*, **8**, 548.

——— and Bhutt, 1942, *Proc Ind. Sci. Cong.*, Part III, Chem. Soc., p. 61,

——— and Murthy, 1942, *ibid.*, p. 64.

———, 1943, *B. H. U. Journal*, **8**, 99.

———, 1944 (*a*), *Curr. Sci.*, **13**, 253.

———, 1944 (*b*), *Nature*, **154**, 147.

———, 1945 (*a*), *Curr. Sci.*, **14**, 67.

———, 1945 (*b*), *Proc. Indian Acad. Sci.*, **A22**, 225.

———, 1946, *Curr. Sci.*, **15**, 281.

———, 1947, *Curr. Sci.*, **16**, 19.

The following special publications of the Indian Association for the Cultivation of Science, 210, Bowbazar Street, Calcutta, are available at the prices shown against each of them :—

Subject		Author	Price Rs.	A.	P.
Methods in Scientific Research	...	Sir E. J. Russell	0	6	0
The Origin of the Planets	...	Sir James H. Jeans	0	6	0
Separation of Isotopes	...	Prof. F. W. Aston	0	6	0
Garnets and their Role in Nature	...	Sir Lewis L. Fermor	2	8	0
(1) The Royal Botanic Gardens, Kew.	...	Sir Arthur Hill	1	8	0
(2) Studies in the Germination of Seeds.	...	,,			
Interatomic Forces	...	Prof. J. E. Lennard-Jones	1	8	0
The Educational Aims and Practices of the California Institute of Technology.	...	R. A. Millikan	0	6	0
Active Nitrogen A New Theory.	...	Prof. S. K. Mitra	2	8	0
Theory of Valency and the Structure of Chemical Compounds.	...	Prof. P. Ray	3	0	0
Petroleum Resources of India	...	D. N. Wadia	2	8	0
The Role of the Electrical Double layer in the Electro Chemistry of Colloids.	...	J. N. Mukherjee	1	12	0

A discount of 25% is allowed to Booksellers and Agents.

RATES OF ADVERTISEMENTS

Third page of cover	...	...	...	...	Rs.	32, full page
do.	do.	...	...	...	...	,, 20, half page
do.	do.	...	...	...	...	,, 12, quarter page
Other pages	...	...	...	...	,,	25, full page
do.	...	...	...	...	,,	16, half page
do.	...	...	...	...	,,	10, quarter page

15% Commissions are allowed to *bonafide* publicity agents securing orders for advertisements.